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ABSTRACT

The Open University of Great Britain is an open-enrollment, home-based institution in which the majority of instruction is conducted via broadcasts and correspondence. As part of an effort to measure the effectiveness of this program, 490 students in a course in mathematical analysis were surveyed to: 1) determine the amount of time students spent on each unit of instruction; 2) identify abnormally difficult sections of the curriculum; and 3) find sections of the curriculum which could be made optional. Details of the survey design and tabular results are provided. (EMH)

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Broadcast Evaluation Report No. 1

"ANALYSIS"
M231

Audio-Visual Media Research Group
INSTITUTE OF EDUCATIONAL TECHNOLOGY
WITH FACULTY OF MATHEMATICS
Open University

R003130

THE OPEN UNIVERSITY

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Broadcast Evaluation Report

No. 1

M231: "Analysis"

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August 1975

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(The Appendices are bound separately, and are available on request from the Audio-Visual Media Research Group.)

M231: "Analysis"

Introduction

This study strictly lies somewhat outside the main evaluation project, in that in the 17 evaluation studies "proper" the Research Group was responsible for the formulation of general evaluation criteria against which the individual programmes were examined in detail. With M231, however, it was the Course Team which approached the Research Group for assistance in evaluating aspects of the course for two specific purposes:

(a) in order to make adjustments to the content of the M231 course in 1975 (the second year of its life)

(b) in order to take informed decisions on the presentation of material for M332 "Complex Analysis" (which was being prepared by the same course team for presentation in 1975).

The two major areas of preoccupation for the M231 course team were:

(1) the amount of work included in the course as a whole, and its organisation

(2) the techniques used in some of the television programmes.

Since the planned third-level course was intended to be presented in roughly the same way, with a similar organisation of work materials and possibly some of the same programme techniques, our brief was to discover what problems students were having in using the M231 materials.

The M231 evaluation, then, was very different in orientation from that of the other studies carried out in 1974.[1] Firstly, it was aimed at finding answers to specific questions raised by the course team. Secondly, it attempted a more global examination of the course as a whole - including the written units - than would have been appropriate to the other more detailed evaluation studies. However, many of the findings from the M231 study contain implications for course design in general, and indeed provided a number of insights for the Research Group as to potentially fruitful areas for investigation in the later, more detailed studies. For these reasons, it is presented as the first broadcast evaluation report of the 1974 series.

The Problems

An original intention of the M231 course team was that certain sections of the units could be made optional. In fact students had been warned that changes would be made to the status of some sections and that these would be identified in the "Stop Press". Consequently, it would be possible to increase or decrease the amount of content in the course to some extent. Accordingly we set out to

(i) determine a 'normal' time for the period of study for a particular unit,

(ii) identify sections in the unit which were abnormally difficult,

(iii) find the 'normal' time of study for those sections of the unit which could be made optional.

---

1. See the General Introduction to any of these reports for a description of the aims, criteria and methods used.

Information on these aspects was intended to make it possible for the course team to adjust the content so that the average time of study per unit complied with the University guide-lines, and to allow removal of or amendment to particularly difficult sections.

The course team had expressed some anxiety about the early television programmes, so it was suggested that particular emphasis be put on the evaluation of the first five television programmes, in order to

(iv) determine what proportion of students claim that a particular television programme was totally unhelpful (or worse).

Resources allowed for the remake of the equivalent of one television programme, so that if the evaluation data so indicated, changes could be made to a programme causing particular problems. In addition, broadcast notes could be rewritten, if necessary, both to help iron out any difficulties in the associated programmes and to deal with problems caused by the notes themselves.

Since each television programme had associated self-assessment questions in the broadcast notes, time spent on this work might have added noticeably to the overall study time for any particular unit. It was therefore decided to

(v) obtain a 'normal' time for study associated with a particular television programme.

Information gained here could be used to make adjustments to the contents of the broadcast notes.

In the case of the eight radio programmes in the course, the same sorts of question were raised. Additional evaluation aims were therefore

(vi) to determine what proportion of students claim that a particular radio programme was totally unhelpful (or worse)

(vii) to obtain a 'normal' time for study associated with a particular radio programme.

Broadcast notes could be altered and several radio programmes remade if this proved necessary.

Turning now from the specific problem of making possible adjustments to an already made course, to the more general issue of the presentation of future courses, the course team was anxious to know how students had reacted to particular production, organisation and presentation modes used in M231. Five specific areas for investigation were identified:

(1) Pacing mechanisms used by students.

The television programmes for M231 had been scheduled for transmission on the assumption that students do not study the correspondence units in the weeks officially suggested in the course calendar (Appendix A), but that they lag behind and pace themselves against the submission dates for tutor-marked assignments. Was this a valid assumption?

(2) Use of self-assessment questions.

The printed units, television and radio programmes all had associated self-assessment questions (SAQs) in the broadcast notes (an example of broadcast notes is in Appendix B): those in the unit texts were described by the course team as "absolutely trivial". Did students actually use all or any of these SAQs, and how helpful did they find them?

(3) The television programmes.

The eleven television programmes were planned to concentrate on some of the more difficult items in the course. In general they discussed and illustrated the solution of particular mathematical problems and/or dealt with the proof of theorems. Two quite different production techniques were used to cover these separate programme functions. The "problem-solution" was dealt with in a conventional "pen and paper" manner by showing a course team member actually working through problems step by step and giving some verbal explanation of what was happening at each stage of the solution. The "proofs", on the other hand, were demonstrated by a novel and rather complex technique, which we can call "silent animation". This involved presentation of the proof by means of the animated manipulation of the various component signs and symbols, so that particular parts of the theorem relevant to any specific stage of its proof were highlighted sequentially. Very little academic commentary - indeed in some cases none at all - accompanied the visual presentation, the intention being that its absence would provoke students into thinking more carefully than they might otherwise do about the general strategy of the proofs. How did students react to these two very different television techniques?

(4) The radio programmes.

These eight programmes were intended to be problem-oriented rather than discursive; that is, they were planned to help students over difficulties with the mathematical problems in the units. The associated broadcast notes contained material which students were expected to follow while actually listening to the programme. Did students, in the first place, listen to the radio programmes? If they did, how helpful did they find the programmes? Did they have any difficulty in following the material in the broadcast notes during the programmes?

(5) The tutor-marked assignments.

Each assignment (TMA) contained one non-assessed problem which students were told could well be an examination question (only longer). Did students in fact attempt these non-assessed questions or did they find them frighteningly difficult?

Information on these five particular areas would assist in decision-making on the organisation and presentation of future courses, notably M332, in the Mathematics Faculty, and should also provide insights into some of the problems faced by Open University course designers in general.

Method

It will be clear from the preceding outline that this particular study presented a number of problems in terms of selection of appropriate data collection instruments and methods. Firstly, while much of the requested information indicated the need for a year-long study (for example, to establish study times or difficulties of particular units of work), the course team needed some of the other data (for instance, for the remake of programmes and for decision-taking on the third-level course planned for 1975) as early as May or June of 1974. Secondly, although to answer some of the questions (the issue of the television techniques, for example) a fairly detailed approach seemed appropriate, many other aspects (usage of various components, study pattern) could be adequately covered by a series of pre-coded options to questions. Thirdly, the number of students registered for M231 - 769 at the beginning of the academic year - did not allow much leeway in the selection of the necessary student samples.

After discussion among the evaluators and the course team, it was decided that use of several different data collection techniques was indicated and that the evaluation should be carried out in stages to coincide with the course team's deadlines for receipt of the various pieces of information. The methods used were as follows:

(a) A random sample of 490 students registered for the course in February, 1974, were each sent a pad of Course Unit Report Forms (CURF) at the beginning of the year. The form, although for data processing purposes necessarily designed along the standard lines used for all CURFs, covered the specific M231 problem areas which could be tackled by closed-option questions. (Appendix C). Students were asked, in a letter - signed by the Course Team Chairman - accompanying the pad of forms to complete a form for each unit of work from Unit 3 onwards. (Spare CMA cells had been used to ask questions on Units 1 and 2: this data is included in Appendix H). These report forms gave information on difficulties with the written material, dates of study and hours spent on various course components, use of SAQs and reactions to television and radio programmes. While most of the answers were pre-coded, there was space for a small amount of open-ended comment. This has been typed up and is provided in Appendices J, K and M.

At the beginning of the year, 16 students wrote letters of refusal to take part in the survey. Letters were sent to students who had agreed to participate, at the beginning of May and in mid-June, reminding them to return their completed report forms. Even at the beginning of the year, the response rate was a disappointing 48%, with 235 students returning usable forms for Unit 3, TV2 and Radio 2. Throughout the year, the rate of return deteriorated (Table 1) so that only 21 persistent students returned the final report form, covering Unit 16 and TV11.

Table 1: Students Returning Course Unit Report Forms

Form number	Components covered	Responding students	Original sample	Response rate	Registered students	Adjusted* response rate
1	U3,TV2,R2	235	490	48%	769	48%
2	U4,TV3	219	490	45%	767	45%
3	U5,TV4,R3	210	490	43%	763	43%
4	U7,TV5,R4	179	490	36%	763	37%
5	U8	148	490	30%	746	30%
6	U9,TV6,R5	144	490	29%	746	30%
7	U10,TV7	109	490	22%	740	23%
8	U11,TV8,R6	97	490	20%	740	21%
9	U13,TV9,R7	71	490	14%	740	15%
10	U14	63	490	13%	723	14%
11	U15,TV10,R8	33	490	7%	723	7%
12	U16,TV11	21	490	4%	661	5%

* The adjusted response rate assumes that students in the sample withdrew in a similar proportion to the total course population.

Even with an adjustment to allow for withdrawal from the course throughout the year, the response rate is poor. Of course, the number of students actually registered for a course is not always an accurate reflection of the number of students seriously following that course: for instance, although 661 students were officially registered for M231 at the end of October, only 546 actually sat the end of course examination at the beginning of November, i.e. 17% of registered students were not examined. However, further adjustment to allow for this makes very little difference - e.g. the finally adjusted response rate for Unit 16 is pushed up to 6% - because of the very small numbers returning forms at the end of the year. However we look at the data then, we are forced to conclude that it must be treated with great caution for the second part of the year in particular: while a calculation of two standard errors on a range of data from the first report form indicates sampling errors of between $\pm$ 3% to $\pm$ 5% at the 95% level of confidence, the same calculation for the final CURF indicates an error range of $\pm$ 13% to $\pm$ 21% (i.e. if 50% of those returning the last report form said that they saw TV11, we can be 95% certain that between 29% and 71% of the total student population saw the programme). Clearly, this is such an enormous margin of error that the data is virtually worthless. However, up to and including CURF number 8 (that covering Unit 11, TV8 and Radio 6) maximum sampling errors are below $\pm$ 10%.

(b) Five separate random samples of just under 60 students registered for the course in February, 1974 were each sent a more detailed questionnaire covering one of the first five television programmes and, in the case of four of the samples, one of the first four radio programmes in the course. No individual student, then, was asked to fill in more than one of these more detailed questionnaires, nor were any of the students in these five samples included in the larger sample to whom CURFs had been sent. These questionnaires (referred to subsequently as "broadcast questionnaires" or "BQs" - Appendix D) asked for students' detailed and specific reactions to the television and radio programmes and also enquired about dates of study of the various units. As a cross-check some of the questions asked were identical to those asked on the CURFs, but there was much more space for open-ended comment, and these are provided for reference in Appendices L and N.

Students who had not returned their questionnaires at intervals of ten days and twenty days after the last transmission of the relevant programme were sent letters reminding them to do so. The response rate here was good, ranging from 91% to 79% (Table 2) when adjusted for students who had withdrawn from the course by the time of the relevant broadcast.

Table 2: Students Returning Broadcast Questionnaires

Questionnaire number	Programmes covered	Responding students	Total sample	Response rate	Students withdrawn at broadcast time	Adjusted response rate
1	TV1	49	58	84%	2	87%
	R1					
2	TV2	50	59	85%	1	86%
	R2	51		86%		88%
3	TV3	49	59	83%	5	91%
	R3					
4	TV4	47	59	80%	2	82%
5	TV5	45	59	76%	2	79%
	R4	46		78%		81%

Because of the small numbers in each of these five samples (each sample representing about 8% of the total student population) the sample errors are rather large (within the range ± 8% to ± 14% at the 95% confidence level). However, other studies in this series [1] have found that high response rates are necessary to ensure accurate measurement of viewing and listening figures: for example, there is a tendency for non-respondents to withdraw or to do less well in the final course assessment than

1. See for example, Bates, A.W. 1975, Broadcast Evaluation Report No. 3. T291 "Instrumentation".

students who respond to questionnaire surveys; moreover, students who subsequently withdraw are less likely to watch television and - particularly - listen to radio broadcasts [2]. Consequently, a low response rate is likely to give a biassed picture of actual student behaviour, even though, as we have seen, the theoretical sample error may be relatively low. For this reason we believe that the data from the 80% to 90% of students returning the broadcast questionnaires reflects, with reasonable accuracy, the actual behaviour (in terms of viewing and listening) of the total 1974 M231 student population, and of its reactions to the television and radio programmes in question.

(c) A random sample of 40 students with telephones, registered for M231 in the middle of May 1974, was selected to be interviewed using a schedule (Appendix E) which had been piloted at a Saturday School in Cambridge study centre in the previous March. The interviews were intended to delve more deeply into reactions to the M231 radio and television techniques than was possible through the postal questionnaires. A further aim was to supply the course team with additional information on the use of SAQs in order to help take a decision dictated by a print deadline for M332. In addition, detailed questions were asked about TV5, the programme broadcast immediately prior to the telephone interviews: an analysis of students' answers is presented separately, in Appendix F.

Of the 40 sampled students, 3 said they had withdrawn or were about to do so and 2 could not spare the time to be interviewed. A further 10 - despite persistent efforts - could not be contacted during the interview period 21st May to 2nd June. Interviews were thus obtained with 25 of the original sample.

RESULTS

WORK PATTERN AND STUDY TIMES

Information collected in the study suggests that the M231 course team was correct in assuming that students "lag behind" course calendar starting dates. (see p. 2).

We concentrate here on data from the Course Unit Report Forms for Units 3-7 represented graphically in Figure 1 (overleaf). Because of the lower reliability of the data returned for later units in the course (see p. 5) this information has been drawn on only to provide occasional comparison with the pattern indicated by the data for earlier work units.

Suppose we consider various hypotheses about the way students schedule their work. One hypothesis might be that students work roughly to the schedule of

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2. Gallagher, M., 1975, Broadcast Evaluation Report No. 4. S24-: "Industrial Chemistry Component".

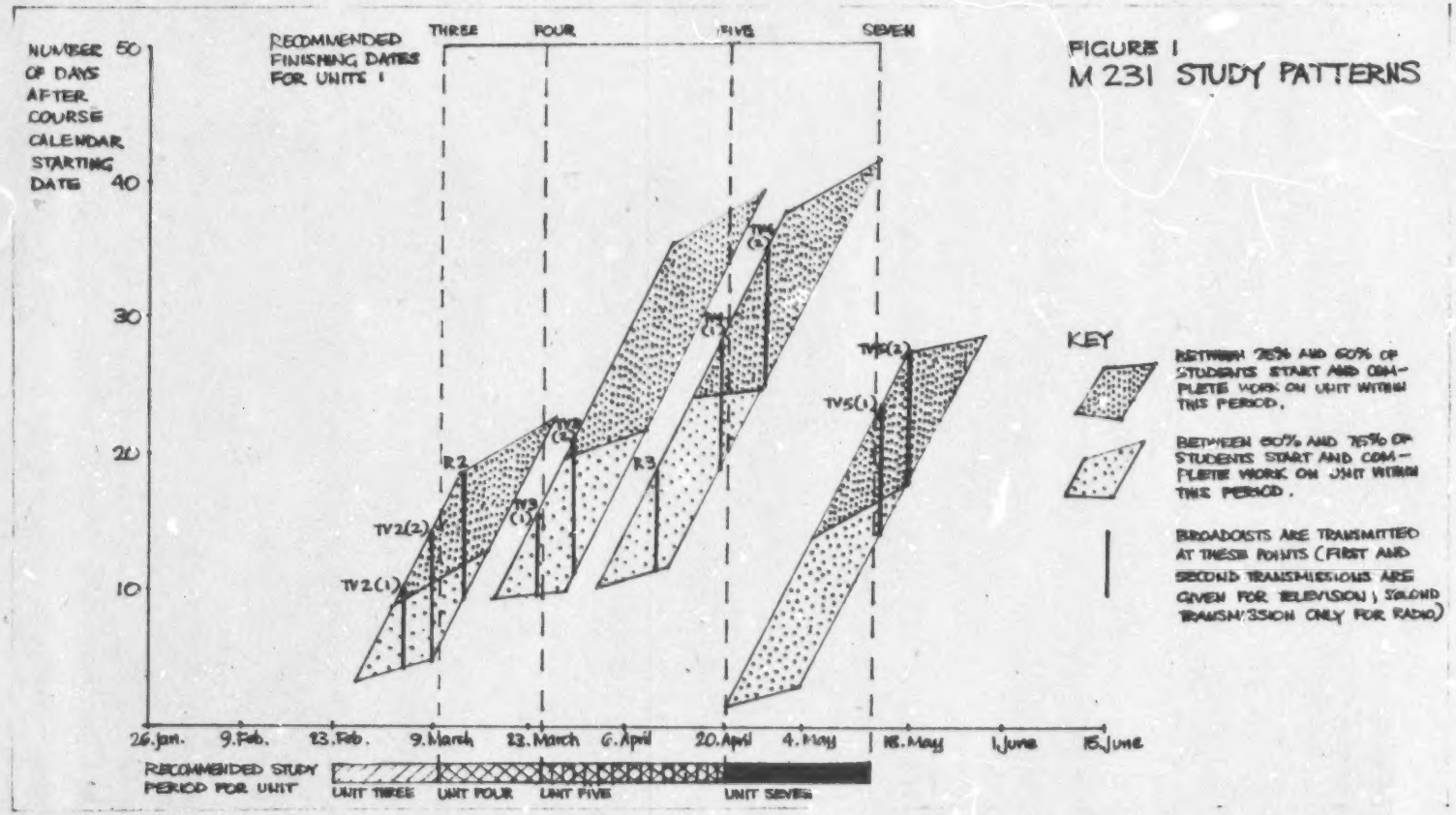
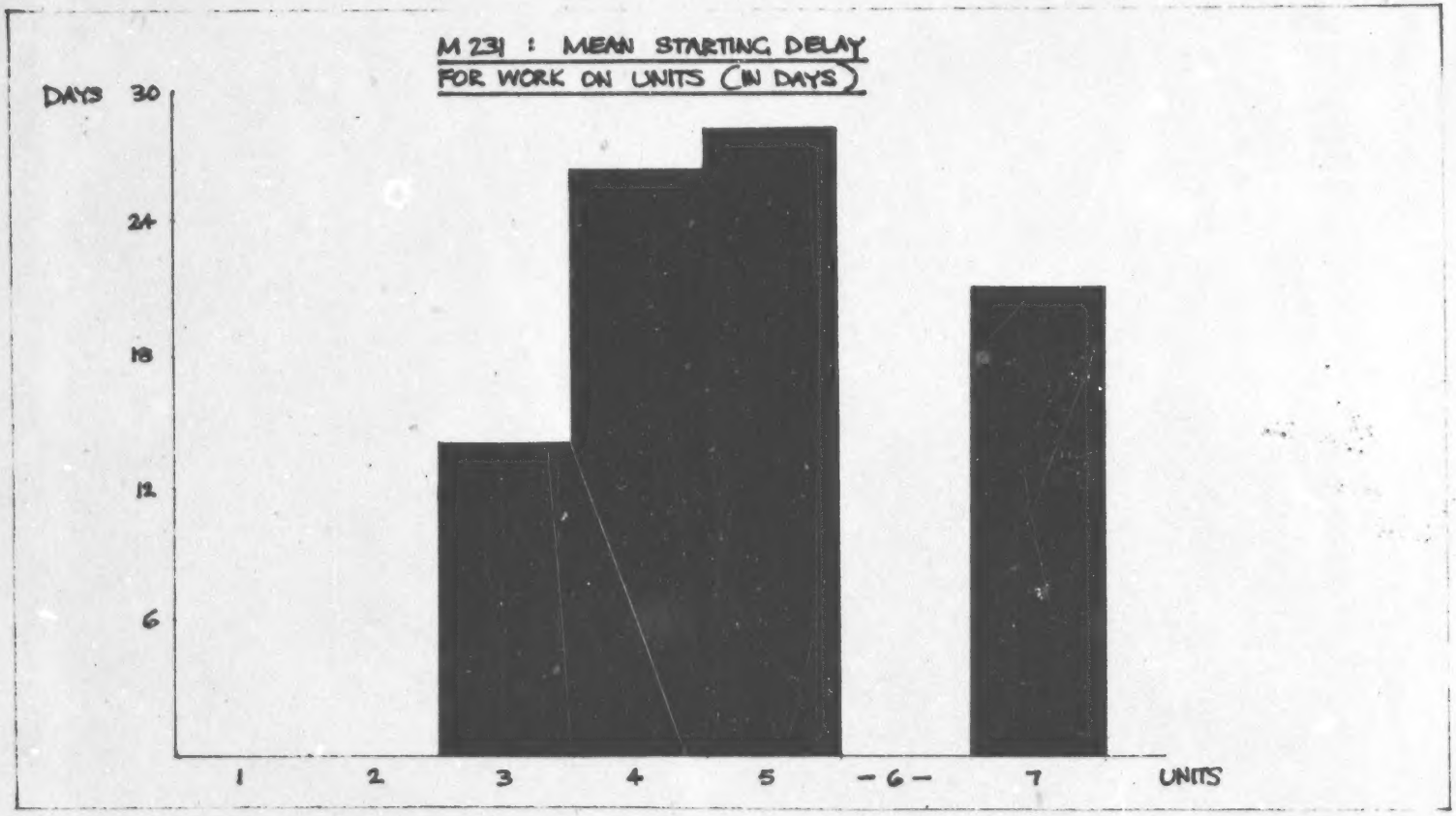


FIGURE 1
M 231 STUDY PATTERNS

FIGURE 1


M 231 : MEAN STARTING DELAY
FOR WORK ON UNITS (IN DAYS)
DAYS
30
24
18
12
6
1
2
3
4
5
6
7
UNITS

course calendar start dates suggested by the course team. However, Figure 2 (p. 9) shows that already by the beginning of Unit 3 there was a mean starting delay (from the scheduled start date) of 14 days. The mean delay increased dramatically to 26 days for Unit 4 - possibly exacerbated by the exceptional difficulty students had with Unit 3 (see p. 12). By the beginning of Unit 5 mean delay was 28 days - students were starting on average 4 weeks after the scheduled start date. For Unit 7 the mean starting delay had been reduced to 21 days: students may have been helped by the "break" between Units 5 and 7 (there was no text for Unit 6 so that students would have time for catching up, consolidation or further work.) Moreover, the fact that Unit 7 is the last Unit covered by TMA 02 is important (see p. 11). The conclusion must be that students do not schedule their work according to course calendar starting dates.

A second hypothesis might be that students work roughly in a pattern dictated by the television broadcast schedule. Since at least twice as many students reported watching the first transmission-Monday at 6.15 p.m. - of each programme, than the repeat-Saturday at 9.45 a.m. - we should take the first transmission date of any programme as the scheduling point. In fact, the majority of students had started work on the Unit related to each programme by the time of its first transmission (Table 3)

TABLE 3: Percentage of students working on Unit related to TV

First transmission: / Related to:	TV2 Unit 3	TV3 Unit 4	TV4 Unit 5	TV5 Unit 7
Students Working : On Unit	64%	50%	72%	70%

However, it seems unlikely that the television transmission date is, in fact, a crucial scheduling point for students. In the first place, the television programmes were actually scheduled on the assumption that students would work behind the recommended starting dates for units: that is the first broadcast of any television programme took place between 1 and 4 weeks after the recommended start date for study of its related correspondence text. It was therefore to be expected that a respectable number of students should have reached the relevant unit by the time of the first transmission of each programme: it is perhaps a cause for concern that up to 50% had not done so. (e.g. in the case of TV3 - even though this programme was transmitted 14 days after the scheduled start date for Unit 4 and even though 75% of students had finished work on Unit 3 by that time, see Figure 1). An even "lower" point was reached for Unit 9 and its associated programme, TV6: at the time of the first transmission of TV6, only 38% of students had started work on the related Unit 9. In each case (TV3 and TV6) the programmes coincide with the

cut-off dates for TMAs covering previous units: it appears that these, rather than TV broadcasts, are the really important dates for students.

This leads to the third hypothesis: that students work to TMA due dates, or cut-off dates. The first tutor-marked assignment, TMA 01, covering units 1-3 was due on March 19th, and the cut-off date was April 5th (scheduled start for Unit 4 was March 9th). TMA 02, covering units 4-7 was due on May 21st, and the cut-off was June 6th (scheduled start for Unit 8 was May 11th). In each case, 75% of students had finished work on the last unit for each TMA (i.e. Units 3 and 7) at the exact mid-point between due and cut-off dates (Figure 1). In each case, 75% of students had started work on the last unit covered by the TMA before the due-date. The importance of TMA dates in student's work patterns is also indicated by the possibility that students "have a rest" after submitting an assignment: while 75% had finished work on Unit 3 by 27th March, it was 14th April by the time Unit 4 had been started by 75% of students - leaving a "gap" of 18 days (despite the fact that most students were already well behind schedule, and that TV3 - related to Unit 4 - was first transmitted on 26th March). This long gap between finishing work on one unit and starting work on another does not persist between Units 4 and 5 nor between Units 5 and 7. It does, however, reoccur between Units 7 and 8, suggesting that students may well see the assignment submission dates as peaks: after each ascent they may stop for a breather.

Overall then, TMA due and cut-off dates are the best guide as to when the vast majority of students will have looked at, or perhaps even studied, a particular unit.

THE PRINTED UNITS AND TUTOR MARKED ASSIGNMENTS

The Units in General

On the whole, the units were found to be difficult (55% said "very" or "fairly" difficult over all units) and time-consuming (14.4 hours is the median over all units). The study time is spread over ten days (from starting date to finishing date), and includes an average of almost four hours spent on assignments.

Students were asked how long they spent on the Appendix (an optional item). Overall, 39% of students studied the Appendices, though this dropped to 31% in the case of Unit 7, possibly because of pressure from the TMA 02 cut-off date. The median study time for the Appendix was one hour.

At the beginning of the year, it was planned to make optional a number of other items - up to 3 per unit - these were to be announced via Stop Press. In fact, only two of these "stop press optionals" were announced, both in Unit 8. The fact that question 6 on the Course Unit Report Form asked about study times for possible optional material throughout the year, makes interpretation of data for Unit 8 highly dubious. The very high number of "no responses" may be accounted for by students who got used to ignoring this question: some of these non-respondents may in fact have studied the optional items. For Item A, 18 out of 45 respondents said they studied the section: the median study time was 1 hour. For Item B, only 6 of the 45 respondents said they studied the section: 3 of these spent under 30

minutes on it, 1 spent between 30 and 60 minutes, 1 between 1 hour and 1½ hours, and 1 between 1½ and 2 hours.

Individual Units

Results for individual units are given in Table 4 overleaf. Scores for Units 13 onwards must be treated with caution due to the small number of respondents.

Of the early units, number 3 can be seen to be extreme in several ways - e.g. most difficult and most time-consuming. 26% of students spent over 20 hours on this unit, and 9% spent over 30 hours on it. Generally, results seem to accord with expectations that limits and continuity (Unit 3) are difficult concepts, differentiation (Unit 5) straighforward, and Riemann integration (Unit 8) involves long-winded calculations.

Difficult Sections

In Unit 3 the overwhelming difficulty was with the concept of limits and the epsilon/delta techniques. Further, more general, comments on the units indicate that students found Unit 3 something of a shock after the relatively easy first two units: in fact a number of students said that this was the most difficult unit met in any Open University course so far (M100, M201, M202, M251 were mentioned in comparison).

In Unit 4, a number of students had difficulty in applying the method of repeated bisection, but the majority had general difficulty in following the proofs, particularly in Section 5. There was also general difficulty with the problem sections.

With Unit 5, areas emerging as problematic were Section 5 (proof of the Chain Rule) and Section 9 (directional derivatives), but general comments on the unit indicate that on the whole students found it interesting and enjoyable.

In Unit 7, sections 4 (Darboux's Theorem) and 8 (implicit functions) gave most trouble, but again on the whole this was one of the less difficult units in the course.

Two specific points of difficulty were mentioned for Unit 8: firstly the partition arguments - in some cases just their application - were found difficult, and secondly the double integral was said to be confusing.

In Unit 9 the most frequently specified difficulty was that of grasping the meaning of the characteristic function. A few students felt that there was insufficient explanation and not enough examples of arc lengths.

Logarithmic differentiation and the domains of inverse functions gave trouble in Unit 10. Generally, however, students were fairly happy with this particular unit.

There was general approbation for the opportunity for both revision and practice afforded by Unit 11 - found by many the easiest unit of the course. A general comment was the sense of relief and encouragement gained from being able to apply well-learned techniques, and many found the unit enjoyable after the 'abstractness' of previous material.

TABLE 4: REACTIONS TO UNITS 3 - 16

UNIT	3 Limits and Continuity	4 Continuous Functions	5 Differentiation	7 Applications of Derivative	8 Riemann Integral	9 Properties of Integral	10 Some Important Functions	11 Techniques of Integration	13 Taylor Approximations	14 Sequences and Series	15 Uniform Convergence	16 Revision
Total study time (median) in hours	16.4	14.6	14.0	14.8	13.6	13.8	13.4	14.3	15.2	17.0	11.7	11.2
Assignment time (mean) in hours	4.5	3.7	3.2	3.8	4.1	4.0	3.8	3.8	4.1	4.6	2.1	0.5
Difficulty score (high=difficult)	98	86	41	63	73	77	50	30	74	104	96	19
Difficult sections (*=more than 20% mentioned)	1*2*3,4,7	4,5* 7	5*6,7,9	4,8	6	1,2,3,5	1	-	4	2,5,6*	1*	-
SAQ difficulty score (high= difficult)	70	61	35	51	64	64	37	40	54	90	79	29
SAQ usefulness score (high= useful)	122	121	126	147	107	105	116	148	126	104	126	138
TMA question for unit (mean score)	5.7	5.9	9.2	9.1	7.3	5.5	8.2	7.8	7.5	6.3	No question	No question

Comments on the other units are not dealt with here, because of the low number of responding students. All comments are, however, available in Appendix J .

Self Assessment Questions and Problems

Overall, 45% of students found the SAQs very or fairly difficult. Difficulty of SAQs relates positively to difficulty of unit (e.g. of the early units, SAQs for Unit 3 were found most difficult, and those for Unit 5 least difficult - Table 4). The vast majority of students found the SAQs very or fairly useful (85%). Usefulness of SAQs was also related to their difficulty: easier questions tended to be rated more useful. (see p.32 for further correlation analyses).

Students' comments indicate that these SAQs were indeed a success - boosting morale which had been lowered by the more difficult problems. Altogether, the impression gained from the comments is that students found the problems both too many and extremely difficult - therefore time-consuming. On the other hand, students seemed to lack the confidence to "select", and were uneasy about skipping any problems, despite the optional nature of some of the problem sections.

Tutor-Marked Assignments

The course team had included one non-assessed question in each of the four tutor-marked assignments. Such questions were rather more difficult than the other assignment problems and were intended to prepare students for the sort of questions which they would meet in the final examination. However, as Table 5 shows, only about half of those returning the assignments attempted the non-assessed questions, a disappointing proportion when compared with the number of students tackling such questions in assignments for M100, M201 or MST281.

Table 5: Tutor Marked Assignments for M231

TMA	No. students submitting assignment	No. attempting non-assessed question	% of total attempting non-assessed question	Mean assignment score
1	699	409	59%	7.1
2	522	245	47%	8.1
3	378	187	49%	7.0
4	364	184	51%	7.1

Each question in the assignments covered the content of a particular work unit in the course. If we look back at the last horizontal column of Table 4 (p.13) we see that the units which caused most difficulty to students, had the lowest assignment question means: Units 3, 4, 9 and 14 had particularly low means. Each of these four units was covered by a different one of the four TMAs.

It is possible, then, that the difficulty which students had with these four units, the high study time spent on each - median times of between fourteen and a half and seventeen hours - both contributed to the extent to which the majority were working behind schedule and decreased students' inclination to attempt the non-assessed questions in the four assignments.

THE TELEVISION PROGRAMMES

Viewing Figures

Both sources of information used in the study (CURFs and BQs) show a fairly high initial viewing audience, falling off quite rapidly after the first few programmes. The broadcast questionnaires provide data on the first five programmes (Table 6)

Table 6: Students viewing first five television programmes (BQs)

	TV1	TV2	TV3	TV4	TV5
Total respondents	49	50	49	47	45
Number viewing	41	39	33	30	26
% viewing	84%	78%	67%	66%	58%

The CURF figures are consistent with these, and show that the non-viewing trend suggested by the broadcast questionnaire data continues throughout the year. [3]

Table 7: Students viewing last ten television programmes (CURFs)

	TV2 %	TV3 %	TV4 %	TV5 %	TV6 %	TV7 %	TV8 %	TV9 %	TV10 %	TV11 %
% Viewing	75	63	59	64	60	55	40	65	81	74

Reversal of the trend between TV4 and TV5 may be due to the fact that students had begun to "catch up" to some extent by the time of transmission of TV5: by the time of its 2nd transmission, 75% were working on the related Unit 7 (see Figure 1). Alternatively, this may be not so much a reversal as a re-establishment of the real trend. TV4 may be artificially low because of the fact that there was a three week delay between TV3 and TV4, instead of the previously established 2 week delay. This may have caused a number of students to miss the programme unexpectedly.

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3. Throughout the results, differences between BQ and CURF data are not significant and must be accounted for by the error margin in the sample sizes.

Students were asked, in the broadcast questionnaires, if there was any particular reason for not having watched the relevant television programme. For each of the programmes, most of the reasons (over three-quarters) were concerned with work or family commitments and with inconvenient transmission times. A few students mentioned being behind schedule as a reason for not watching, and a few others said they had not found Open University maths programmes crucial to the courses they had previously taken. No-one gave dissatisfaction with earlier M231 programmes as a reason for not watching a later one.

For all programmes the weekday evening transmission was more popular than the repeat at the weekend. Of CURF respondents, for each TV programme at least twice as many watched on Monday evening (18.15) as on Saturday morning (09.45). Generally, less than a fifth of students watched both transmissions, with the exception of TV2, which was watched twice by a quarter of the students in the BQ sample and by 23% in the CURF sample.

Usefulness of the Television Programmes

As far as overall usefulness of the programmes is concerned, we find that, of those who watched, most students found most of the programmes helpful. Table 7 shows the reactions of BQ respondents to the first five programmes.

Table 8: Usefulness of first five television programmes (BQs)

Numbers rating programme:	TV1	TV2	TV3	TV4	TV5
Very useful	7	2	5	5	5
Fairly useful	21	18	25	14	18
Not very useful	13	12	1	10	2
Not useful at all	0	7	1	0	0
Don't know	0	0	1	1	1
Total	41	39	33	30	26

Percentage results from CURF data show that reactions of the two groups of respondents are broadly similar and that TV2 clearly stands out as being least useful.

Table 9: Usefulness of last ten television programmes (CURFs)

Percentage rating programme:	TV2 %	TV3 %	TV4 %	TV5 %	TV6 %	TV7 %	TV8 %	TV9 %	TV10 %	TV11 %
Very useful	8	17	22	23	27	26	35	29	16	36
Fairly useful	30	59	54	62	48	56	49	53	64	50
Not very useful	35	18	19	13	14	11	8	16	20	-
Not at all useful	26	4	3	-	5	2	-	16	20	7
Don't know	1	1	2	-	1	-	3	-	-	-
No answer	-	2	1	2	5	5	5	2	-	7

In order to allow us to probe the relative usefulness "ratings" of the various programmes, (e.g. to know whether a low rating was related to programme content or style or perhaps to some other, external, factor) students - in both BQs and CURFs - were asked to say why they had found any particular programme "not useful". A gloss of these comments for each programme is given below. A complete list of verbatim comments is provided in Appendices K and L.

TV1

The general theme of these reasons was that the programme was too general, contained nothing new, and came too late, i.e. when work on Unit 1 had already been completed. Several students commented that this introductory programme was interesting rather than useful.

TV2

Almost all the reasons students gave for not finding TV2 useful were related to the silent animations, in particular to the pace at which they developed, and the impression of "jumpiness" or "flashing" which the sequence of changes of lines in the proofs seems to have engendered.

TV3

In this case, most of those who found the programme not useful said that this was because they had not done the necessary pre-study of Unit 4. This agrees with our earlier finding that students tended to get "bogged down" with Unit 3.

TV4

Proof of the chain rule gave trouble - some said it was too fast, others that not enough explanation was given of certain steps in the proof (e.g. the introduction of the function called ϕ in the broadcast notes). There was some feeling that the programme stuck too closely to the methods and approaches to problems and theorems that they had already seen in the textbook. Again, there were several people who had not yet studied Unit 5.

TV5

Very few comments were received here: (this was in fact, found to be one of the most useful programmes in the course). The most common reason given

for not finding it useful was that the programme followed the textbook too closely. Again, the scheduling factor was relevant: for a number of students the programme was screened too late in relation to their study of the relevant printed material.

TV6

Here again, those who did not find the programme useful were almost all students who had fallen behind the recommended work schedule and had not studied the relevant text before seeing the programme.

TV7

This programme was generally criticised as having moved through the material so quickly that it was impossible to follow the details. Moreover, both transmissions were on Saturday mornings, a fortnight apart. This unusual transmission pattern led to difficulties for some students: of those who normally watched both broadcasts, some inadvertently missed the first showing while others forgot to watch the repeat because of the long delay.

Very few comments were received on the remaining television programmes: they are all included in Appendices K and L.

Reactions To Animated Proofs

An attempt was made in the broadcast questionnaires and telephone interviews to learn how students reacted to the presentation of proofs by means of the manipulation or animation of words and symbols, as distinct from the more usual graphical animation.

The overall impression gained was that students were not violently against the technique as such (nor were they fervently in favour of it), but that a substantial number of them felt that those animations they had seen in TV programmes 1-5 were too fast. In particular, the speed of the animated proofs in TV2, together with the fact that all such proofs in TV2 were silent, was the main reason why a large number of students classed this programme as not useful. When animated proofs were voice-accompanied, students seemed to be much happier with them.

It is quite likely that the widespread unfavourable impression of TV2 coloured students' responses to the question of animation technique as used in later programmes (especially TV3), and this should be borne in mind in the interpretation of the results which follow.

One of the major aims of the animation technique was to increase students' concentration during these animated sections of the programme and hence make them think harder about the theorems than they might otherwise have done. Students were divided in the extent to which they felt that the animations were successful in this respect.

Table 10: Success of Animations in Increasing Concentration * (BQs)

Number rating animations as:	TV1	TV2	TV3	TV5
Very successful Fairly successful	8 23 } 31	1 12 } 13	2 11 } 13	3 13 } 16
Not very successful Not at all successful	8 0 } 8	16 10 } 26	11 9 } 20	7 2 } 9
No answer	2	0	0	1
Total	41	39	33	26

* No silent animations were used in TV4.

It appears that the animations have not been entirely unsuccessful in this aim, though it is difficult to say just how successful they have been in view of the generally negative reactions to TV2 and the possible "hang-over" effect on TV3. Note, for example, that the animations in TV1 particularly, but also in TV5, were rated as having been on the whole successful in their aim of increasing concentration.

The producer of the programmes, aware that student reactions to the animation technique might well be negative, wanted to know whether such reaction might actually have interfered with the learning process, or whether the proofs demonstrated through animation, nevertheless remained in viewers' memories. Students were therefore asked which animated proofs, from a given list, (not in the order shown here) they recalled as having been in the programme on which they were reporting. They were asked not to refer to the broadcast notes when answering the question. The results, as shown in Table 11 overleaf, indicate that recall was generally good. Students filled in their questionnaires up to three weeks after viewing the programmes: the amount of error in allocating particular theorems to particular programmes is therefore not great.

The technique having been established in the first few programmes, respondents to the final two broadcast questionnaires were asked how useful, in general, they found this animated demonstration of proofs.

Table 11: Proofs Demonstrated by Animation: Students Allocation of Proofs to Programmes

	TV1	TV2	TV3	TV4	TV5
No. responding to this question	38	36	32	29	24
$\sqrt{2}$ is irrational (was in TV1)	37	6	1	3	0
f,g continuous f,g continuous (was in TV 2)	1	32	2	1	1
f,g continuous fog continuous (was in TV2)	1	28	0	1	0
$\sqrt{x}$ is continuous (was in TV2)	5	25	1	0	1
Intermediate value Theorem (Theorem 7-1) (was in TV3)	5	1	28	1	1
Chain Rule (was in TV4)	0	0	1	27	1
Leibnitz' formula (was in TV4)	0	0	1	24	2
Rolle's Theorem (was in TV5)	0	0	0	0	24
Mean Value Theorem (was in TV5)	1	1	3	2	24
$\|a+b\| \leq \|a\|+\|b\|$ (Not proved in any programme)	1	2	0	1	1
f continuous, $[a,b]$, f bounded on a,b (Mentioned, but not proved, in TV3)	1	1	15	0	0
f,g continuous f + g continuous (Stated, but not proved, in TV2)	0	17	2	1	0
$f'(x) > 0$ for $x \in (a,b)$ f increasing on (a,b) (Proved in TV5, but not using animation technique)	0	0	4	0	15
f,g differentiable, $(fg)' = fg' + f'g$ (Used but not proved)	0	0	1	7	1

Table 12: General Usefulness of Animated Demonstration of Proofs (BQs)

Numbers rating animations as:	TV4	TV5	Both Programmes
Very useful	7	5	12 } 29
Fairly useful	8	9	17 }
Not very useful	10	8	18 } 24
Not useful at all	4	2	6 }
Don't know	0	1	1
No answer	1	1	2
Total	30	26	56

Respondents were clearly fairly evenly split in their estimates of the general usefulness of the technique.

A final question concerned the pace at which the animated proofs developed.

Table 13: Overall Pace of the Animated Proofs

Numbers finding the animations:	TV1	TV2	TV3	TV4	TV5
Altogether too fast	2 } 15	17 } 35	5 } 21	5 } 19	1 } 10
Too fast in places	13 }	18 }	16 }	14 }	9 }
About right	24	3	10	8	14
Too slow in places	2	0	3	4	1
Altogether too slow	0	0	0	1	1
No answer	1	1	2	1	0
Total	42	39	36	33	26

Note that even in TV 5, where the few animated proofs used in the programme were accompanied by graphs as well as by voice commentary, still almost half of the students would have liked things slowed down, while the proportion holding this view is even higher for the other programmes (except TV 1).

On balance, it appears that the animation technique was not completely rejected by viewers, though undoubtedly the pace at which the animations developed in TV2 caused grave problems - indeed problems of a lesser magnitude were caused by the pace of the animations in all programmes covered by the broadcast questionnaires. There is nothing to suggest that students in general were particularly 'for' or 'against' this technique, although some students definitely did seem to dislike it. Also, it seemed possible that the technique might indeed have increased concentration; certainly students did not appear to have difficulty in recalling proofs demonstrated in this way. However, in view of the novelty

of the technique and the fact that students were "immersed" in it very early on in the course (in TV2 - a further complication being that this programme dealt with the epsilon/delta techniques which students found particularly difficult in Unit 3) it is extremely difficult to distinguish between inherent disadvantages of the technique itself, and problems caused by the way in which it was introduced and applied in M231.

Problems Worked Through By Presenter

Students were specifically asked how useful they found it to see problems being worked through by a presenter. The general impression gained from both questionnaire and interview responses was that this technique was certainly appreciated, primarily since this was the method most likely to assist students in gaining some idea of how to go about "tackling" problems - the principal overall difficulty which students appeared to have with the course in general.

Table 14: Usefulness of Problems Worked through by Presenter (BQs) *

Numbers rating the technique as:	TV3	TV4	TV5	All programmes
Very useful	16	9	13	38
Fairly useful	15	13	11	39
Not very useful	0	5	2	7
Not useful at all	0	3	0	3
Don't know	1	0	0	1
No answer	1	0	0	1
Total	33	30	26	89

* Question not asked on BQs 1 and 2.

Some students said that they preferred this kind of presentation to the use of animation because it resembled more closely a tutorial or classroom situation and was valued for the sense of personal contact provided. Several said that they were accustomed to this manner of presentation and therefore knew what to expect from it.

Some specific problems worked through in TV3, TV4 and TV5, were mentioned by students as being particularly helpful.

Table 15: Problems Helpful to Students in TV3-5

TV3	Helpful as concrete example of abstract ideas	Helped to do other work	Helpful for Revision	No. of times mentioned as being helpful
Problems 7-17 p.109 of Spivak (Note 3 in broadcast notes)	4	3	1	8
Theorem 7-1 (Note 4 in broadcast notes)	1	2	1	4
Shoe Fitting l.u.b. example	3	1	1	5

TV4	Helpful as concrete example	Helped to do other work	Helpful for revision	No. of times mentioned as being helpful
Example of Leibnitz formula for derivative of product	4	3	2	9
Using implicit differentiation to find $\frac{dy}{dx}$ if $x^2 + y^2 = 1$ and $f^1(x)$ if $\tan(f(x)) = x$	3	1	1	5
Pascals triangle	0	1	3	4
Differentiation of $\text{Sin}(2x + 1)^3$	2	2	4	8

TV5

Only a few students mentioned anything specific here. The relationship, shown graphically, between Rolle's Theorem and the mean value theorem was mentioned once, and the example of finding the derivative of arctan three times.

Use of Broadcast Notes

Most students (at least two-thirds of BQ respondents and 80% of CURF respondents for any one programme) said that they had, as intended by the course team, read the introduction to the TV broadcast notes before watching the programme. However, rather fewer students attempted the SAQs in the broadcast notes, especially those for the later programmes.

Table 16: Use of SAQs for first five television programmes (BQs)

Numbers who:	TV1	TV2	TV3	TV4	TV5
Used	29	26	17	16	9
Didn't use	10	13	16	14	17
No answer	2	0	0	0	0
Total	41	39	33	30	26

Percentage results from CURFs show the same "dropping off" at TV5:

Table 17: Use of SAQs for last ten television programmes (CURFs)

Percentage who:	TV2 %	TV3 %	TV4 %	TV5 %	TV6 %	TV7 %	TV8 %	TV9 %	TV10 %	TV11 %
Used	71	70	73	64	74	68	81	71	48	64
Didn't use	27	25	25	34	26	30	16	29	44	36
No answer	2	5	2	2	-	2	3	-	8	-

The "dip" for TV5 is difficult to explain, particularly as, like TV8 whose associated SAQs were most widely used, TV5 was rated one of the most "useful" programmes in the course. One possibility is that students were, at the time of the programme's transmission, busy with preparation for their submission of TMA 02. Some confirmation is provided by the other slight "drop" for TV7, transmitted near the due-date for TMA 03. Students were, in fact, asked why they did not use the SAQs for some of the programmes.

Table 18: Reasons for Not Using SAQs. (BQs)

Numbers giving following reasons:	TV3	TV4	TV5
No time	11	6	11
Will use later (for revision)	5	2	2
Not up to appropriate unit	2	2	2
Other	1(a)	2(b)	3(c)

(a) Spent rest of evening after programme on MDT241, and forgot about SAQ's.

(b) (i) Did not follow programme sufficiently well to answer questions

(ii) Understood unit fairly well.

(c) Two said "lazy".
One said - "because I had finished Unit 1 I considered this part of the course closed."

Clearly, then, shortage of time was the major factor preventing students from using the SAQs. The students who used these SAQs did generally appreciate their usefulness: between 80% and 90% of those who used them found the questions "very" or "fairly" helpful. Those few students who gave reasons (in the broadcast questionnaires) for not finding the SAQs helpful, tended to find it too easy to answer such questions immediately after the programme.

Study Time Associated with Television Programmes

In order to determine an approximate normal time of study associated with each television programme, students were asked (in BQs and CURFs), how much time they had spent on the broadcast notes, including SAQs if used, after the television programme.

Median study times have been calculated for those students spending at least some time on the broadcast notes after the programmes.

Table 19: Median time on broadcast notes after last ten television programmes (CURFs)

	TV2	TV3	TV4	TV5	TV6	TV7	TV8	TV9	TV10	TV11
Median time (In minutes)	26	23	26	27	30	27	38	33	24	22

The "high" for TV8 is probably caused by the high proportion of students attempting the SAQs (see Table 17) and the fact that there were more questions associated with this programme than was usual.

Adding to this median about 5/10 minutes for reading the introduction to the notes, we estimate the normal study time associated with the television programmes (excluding the actual viewing time) to be about 30-35 minutes: in other words, each television programmes in M231 represented about one hour's work for the student.

It is interesting to note that there is a consistent positive relationship between the time spent on the broadcast notes after the programme and the usefulness rating given to the programme by the student. On the evidence of the BQ's, we found that for each of the 5 programmes, the average time spent on the broadcast notes was higher for those students who found the programme very useful than for those who did not find it useful.

This suggests that the SAQs are indeed having the desired effect of reinforcing the main points of the programme for those students who spend more time on them. Support for this comes from the CURF data (p33) where a significant positive relationship was found between helpfulness of SAQs and usefulness of the programme.

The Radio Programmes

Listening Figures

The study found a disturbingly low proportion of students listening to the M231 radio programmes, even in the early part of the year. The broadcast questionnaires provide information on the first four programmes in the course.

Table 20: Students Listening to First Four Radio Programmes (BQs)

	Radio 1	Radio 2	Radio 3	Radio 4
Total Respondents	49	51	49	46
Number Listening	30	29	22	14
% Listening	61%	57%	45%	30%

The CURF data confirms that only about three-fifths of students listened to even the first programme and, although reflecting rather higher overall listening figures than those indicated by the BQ data [4], shows that fewer and fewer students listened as the year went on. (Figures for Radio 7 and 8 are not reliable: see p. 5)

Table 21: Students Listening to Last Seven Radio Programmes (CURFa)

	Radio 2 %	Radio 3 %	Radio 4 %	Radio 5 %	Radio 6 %	Radio 7 %	Radio 8 %
% listening	60	53	55	49	43	51	47

This low listening population was confirmed by responses to the telephone interviews, where it was found that 8 of the 25 students interviewed had listened to no M231 radio programmes at all, and that a further 3 had heard only the first programme. Only 6 of the 25 had heard (or at least put on tape) all four programmes transmitted up to the time of the interviews.

The interviewees who had listened to no programmes were asked why this was so, and were specifically asked for their opinions of any other maths radio programmes they might have heard. They were also asked whether they had looked at the M231 radio broadcast notes at all, to discover whether they could have known what kind of radio programmes they were missing.

Most of them had read the broadcast notes, as a possible source of extra help

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4. The CURF data almost certainly presents an inflated picture of listening figures. See p. 5.

in understanding the unit or in doing TMA or CMA questions, so most of those who chose not to listen to any of the programmes were aware of their problem-solving orientation.

Four of the eight said they had not generally found past maths programmes very helpful, although two others thought they were very good. Five of them said they preferred to spend the available time studying the printed units. This was, in fact, the overwhelming impression gained, both from specific questioning and from spontaneous comments made by the 25 students interviewed - radio is regarded as the least essential component of the course, the component to be sacrificed first, the component students are least willing to make an effort to use. This seems to apply even to those students who find the radio programmes helpful.

Among those who did listen to the programmes, preference for one particular transmission slot was by no means as clear-cut as had been the case for the television programmes.

Table 22: Use of Transmission Slots for First Four Radio Programmes (BQs)

Numbers Listening:	R1	R2	R3	R4
Wednesday 7.10 p.m. only	15	15	12	5
Saturday 7.20 a.m. only	10	11	6	4
Both transmissions	2	3	1	3
Taped only	3	0	2	2
No answer	0	0	1	0
Total	30	29	22	14
Taped also	4	4	5	4

The CURF data confirms this general pattern, showing the Wednesday evening transmission to be slightly more popular, just under a tenth of students - on average - listening to both transmissions.

Table 23: Use of Transmission Slots for Last Seven Radio Programmes (CURF)

Percentage listening:	R2	R3	R4	R5	R6	R7	R8
Wednesday 7.10 p.m. only	45	40	52	45	47	43	33
Saturday 7.20 a.m. only	29	33	31	25	21	23	60
Both transmissions	9	8	5	9	13	11	-
Taped sound	17	19	11	22	18	20	7

Note, however, that in all cases, quite a substantial proportion of students listening did so on Saturday morning, even though the broadcast was at 7.20 a.m. (Compare this with the 9.45 a.m. Saturday viewing time). However, the early time of this broadcast was given fairly often as a reason for not listening at all. Also worthy of note is the one-fifth - on average - who recorded the radio programmes on tape.

Usefulness of Radio Programmes

Those students who listened to the radio programmes generally found them useful, and said that the pace was about right.

Table 24: Usefulness of First Four Radio Programmes (BQs)

Numbers finding programme:	R1	R2	R3	R4
Very useful	5)) 26	7))26	6))20	5))11
Fairly useful	21)	19	14)	6)
Not very useful	2	3	2	2
Not useful at all	0	0	0	0
Don't know	0	0	0	0
No answer	2	0	0	1
Total listening	30	29	22	14

Table 25: Usefulness of Last Seven Radio Programmes (CURFs)

Percentage finding programme:	R2 %	R3 %	R4 %	R5 %	R6 %	R7 %	R8 %
Very useful	23))85%	31))83%	38))90%	26))72%	42))89%	29))80%	60))87%
Fairly useful	62)	52)	52)	46)	47)	51)	27)
Not very useful	11	9	4	17	3	14	-
Not useful at all	2	8	2	8	-	-	7
Don't know	1	1	2	2	3	-	-
No answer	-	-	2	2	5	6	7

So no programme stands out as being particularly not useful, although Radio 5 slumps somewhat in relation to the others, for no reason apparent from the comments made by students. Of those students who didn't find the programmes useful, the most common reason given over all programmes was the pace at which they developed, although, in fact, the majority of all students said that this pace was about right. (Table 26).

Table 26: Pace of the First Four Radio Programmes (BQs)*

Numbers finding the programme:	R1	R2	R3	R4
Much too fast	0	0	1	0
Rather too fast	4	4	4	1
About right	22	25	16	11
Rather too slow	3	0	1	1
Much too slow	0	0	0	0
No answer	1	0	0	1
Total listening	30	29	22	14

*This question was not asked on CURFs.

Programme Format

Students who were interviewed were asked for their opinion of the format of the radio programmes. Over half said that they preferred the problem-solving style to any other. Two students would like to have had the main points of the unit discussed as well as hearing problems solved, 2 were specifically unhappy with problem-solving via radio, and 3 called for "motivating" programmes and broadcasts which "linked up" the theorems in the course, in order to give a better idea of its general structure. One of these also liked M100 historical programmes, and would like to have heard something along those lines. Nevertheless, all but the two who had no clear alternative style of programme in mind did find the programmes, as they were, useful.

Use of Broadcast Notes

All but a handful of those who listened to the radio programmes said that they read the introduction in the broadcast notes before listening, and the vast majority also attempted to follow the notes, as instructed, while listening to the programmes: some experienced difficulty in doing so (Tables 27 and 28).

Table 27: Difficulty in Following Notes While Listening to First Four Programmes (BQs)

Numbers finding it:	R1	R2	R3	R4
Very difficult	0	0	0	0
Fairly difficult	2	7	5	1
Not very difficult	17	14	10	6
Not difficult at all	8	7	4	3
Didn't try to follow them	1	1	3	3
No answer	2	0	0	1
Total	30	29	22	14

CURF data is consistent with this general picture:

Table 28: Difficulty in Following Notes While Listening to Last Seven Programmes (CURFs)

Percentage finding it	R2 %	R3 %	R4 %	R5 %	R6 %	R7 %	R8 %
Very difficult	7	10	4	17	-	-	-
Fairly difficult	22	18	21	23	16	23	7
Not very difficult	41	42	36	34	39	46	60
Not difficult at all	25	23	29	23	39	29	33
Didn't try to follow them	2	4	7	2	-	-	-
No answer	2	3	2	2	5	3	-

Consistently, then, about a quarter of those who attempted to do so had some difficulty in following the notes during the radio programmes. There was also a positive relationship between usefulness of programmes and ease of following notes during them: note, for example, Radio 5. This was the programme rated least useful and the one during which students had most difficulty in following the broadcast notes. Apart from the "dip" for Radio 5, there is some slight indication that during the year students "got used to" the activity of following the notes while listening. (Table 28).

About half of those who listened to the radio programmes used the associated SAQs in the broadcast notes. All of those who used them found the questions helpful. Reasons given for not using the SAQs were usually "lack of time", or "saving them for revision", although one or two said they didn't use them because they had not yet reached the relevant printed unit.

Similar findings emerged from the telephone interviews, with slightly more than half the students questioned using the SAQs straight away. A couple of people did not like "filling in boxes", but one was very enthusiastic about this activity. Most thought it was a good idea to have SAQs in the broadcast notes.

Study Time Associated with Radio Programmes

To calculate an approximate normal study time, students were asked how much time they spent on the broadcast notes, including SAQs if used, after each programme. Median study times have been calculated for all those who spent any time on the notes after the programme.

Table 29: Median time on Broadcast notes After First Four Radio Programmes (BQs)

	R1	R2	R3	R4
Median time (in minutes)	29	18	26	30

Table 30: Median time on Broadcast Notes After Last Seven Radio Programmes (CURFs)

	R2	R3	R4	R5	R6	R7	R8
Median time (in minutes)	21	27	25	26	30	35	30

Adding on 5-10 minutes for reading the introduction to the notes, we estimate the normal study time associated with the radio programmes (excluding listening time) to be similar to that found for the television programmes - about 30-35 minutes. So each radio programme in M231 represented just under an hours work for the student.

The relatively low median study time for Radio 2 (over a quarter spent less than 15 minutes on the notes) can possibly be explained by considering the nature of the notes and SAQs for that programme, compared to those for the other programmes in the course. For Radio 2, there were no "boxes" to be filled in, and the SAQs were all of a general nature, whereas for the other programmes, the notes were full of boxes, and the SAQs generally involved calculations rather than definitions and theorems. It is possible, then, that students can more easily resist questions which may involve them in some thought before even the beginning of an answer can be written down.

RELATIONSHIPS BETWEEN THE VARIABLES STUDIED

The information from the Course Unit Report Forms for all 12 units covered in the study, together with their associated television and radio programmes, was computer-analysed on the following 19 variables:

1. Difficulty of units
2. Difficulty of SAQs
3. SAQs not used
4. Usefulness of SAQs
5. Study time (excluding assignments)
6. Time spent on assignments
7. Television programmes not watched
8. Usefulness of television
9. Introductory notes not read before TV viewing
10. Helpfulness of SAQs for television programmes
11. SAQs for television not used
12. Time spent on television notes
13. Television notes not used
14. Radio programmes not listened to
15. Usefulness of radio
16. Introductory notes not read before radio listening
17. Difficulty following notes during radio programmes
18. Notes not followed during radio programmes
19. Time spent on radio notes.

There are three main problems in the interpretation of the data obtained from this analysis:-

(a) the small number of units (12) covered in the study

(b) the small numbers of students actually reporting on these units, particularly the later ones

(c) the fact that there was some variation over the various units, in the students who did respond: not all units were reported on by the same group of students, since some "skipped" reports on particular units and, of course, many students returning early reports did not return later ones.

Nevertheless, we report on some parts of the analysis here[5] since significant correlations were found, confirming findings from other parts of the study and since a number of interesting points are raised about the relative import ce of various aspects of the course components to students' overall study patterns.

Correlations between Unit Variables (1 to 6)

Only one correlation here was found to be statistically significant : difficulty of the unit was very highly related (r = .94) to difficulty of the SAQs for the unit. This is hardly a surprising result, since the SAQs are based on the material contained in the unit. However, a number of other tendencies in relationship are discernible, pin-pointing the difficulty of the unit as the dominant variable which affects all the others.

When the unit is difficult, its study time is increased and more students attempt the associated SAQs. Moreover, a longer time is spent on the assignment question. Where students do attempt the SAQs on easier units, there is a tendency (r = .42) for these SAQs to be rated more useful than those for difficult units. This may be because of the function which SAQs seem to fulfill for students (for example, providing encouragement and support - see p. 14 : students would be unlikely to rate difficult SAQs as "useful" in this sense); or it may be that a favourable reaction to the easier units has been carried over in a similar reaction to the associated SAQs.

Correlations between Television Variables (7 to 13)

A number of significant correlations was found here. It appears that the dominant variable is the proportion watching television. When this proportion is low, those who do watch are more likely to study the broadcast notes, to attempt the SAQs for the programme and to spend more time on the notes. It seems, then, that as television viewing "falls off" throughout the year, students who persist in watching are also persistently active towards the television-related materials. Further, when the viewing proportion is low, viewers rate the television-associated SAQs as more helpful (r=.69) although this is almost certainly affected by the fact that the television programmes themselves are rated as more useful by "persistent" viewers. Moreover, such viewers are more likely to have done the preparatory (broadcast note) reading for the programme.

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6. Significance is attributed to correlations where $r \geq 0.7$ or more

5. Complete correlation matrices are given in Appendix G.

The picture which emerges, then, is of a hard core of television viewers, who may be in some way particularly attracted to the television medium and who consequently enjoy and find useful both the programmes and the related activities. On the other hand, such students may simply be conscientious in their overall approach to their studies, working through all the materials in the recommended sequence and finding them all useful.

Correlations between Unit and Television Variables (1-6 and 7-13)

In general, it appears that increased time spent on the text of a unit reduces the amount of a television-related activity: units which have long study times for the text, and units which have difficult SAQs are such that fewer students study the television notes (r=.65 and = -.63 respectively) and those who do study them spend less time on the notes (r-.63). On the other hand, units which are more difficult have more students watching the associated television programme (r=.72). This seems to indicate that although particularly difficult units may influence more students to watch related television programmes, in such cases students have less time to spare for all of the activities related to the programme itself. It looks as if some students in these circumstances turn to the television programme almost in an attempt just to gain some extra insights or clues into eventual mastery of some particular problem in the printed unit material, rather than with the aim of understanding the full scope and purpose of the television programme in itself.

Correlation between Radio Variables (14 to 19)

Only two significant correlations were found here. Where the proportion listening to radio is low, more time is spent studying the broadcast notes (r=.80). Where students read the notes before listening, they find the notes easy to follow during the programme and the programme itself useful (r= -.95). This corresponds with the finding for television.

Correlation between Radio and Television Variables (7 to 13 and 14 to 19)

Where the listening proportion is low, the proportion viewing is also low (r= .66) However, those who do watch and listen more persistently find the television programmes useful (r= .78) and the associated SAQs helpful (r= .86)

CONCLUSIONS AND RECOMMENDATIONS

The M231 evaluation study set out to answer a number of specific questions raised by the course team about the organisation and presentation of material in the "Analysis" course. The data has enabled us to provide at least partial answers to these questions, and to indicate some possible courses of action to the course team in relation to the M231 course itself and to the proposed third-level course "Complex Analysis". Many of these suggestions were made in an earlier, interim, report to the course team and, where feasible, have already been taken up. We list here the specific recommendations to the course team in relation to the two sets of original questions raised: while the first set of findings and recommendations (A, below) is rather specific in its application to the M231 course, the second (B) is much more general and will be of interest to other course designers in the University as a whole.

SUMMARISED FINDINGS AND SUGGESTED COURSES OF ACTION

A. Questions Raised in Relation to Adjustments to Content of M231

1. What is the 'normal' time for the period of study for a particular unit?

Average study time was found to be high - the median was 14.4 hours over all units. Study time on individual units ranged from a median of 13.3 hours on Unit 10 to 17 hours on Unit 14: indeed, 31% of students spent more than 20 hours on this latter unit and 10% spent over 30 hours on it. Another extremely time-consuming unit was number 3, with a median study time of 16.4 hours: in this case, 26% spent over 20 hours and 9% over 30 hours on the unit. In all cases, study times include an average of 4 hours spent on assignment questions for the unit.

2. Which sections in the unit are abnormally difficult?

Outstandingly difficult overall units were, again, 3, "Limits and Continuity" and 14 "Sequences and Series": almost a quarter of the students rated these as "very difficult". Other difficult units were 4 on "Continuous Functions", 8 on "The Riemann Integral" and 9 on "Properties of the Integral".

Within specific units, particularly difficult sections - mentioned by more than 20% of students - were:

Unit 3, sections 1 and 2:	epsilon/delta techniques and the concept of limits; problems.
Unit 4, section 5:	overall difficulty with problems; also general difficulty in following the proofs and difficulty in applying the method of repeated bisection.
Unit 5, section 5:	proof of the Chain Rule(although this was rated one of the easiest overall units).
Unit 14, section 6:	the problems caused general trouble:

3. What is the 'normal' time of study for those sections of the course which can be made optional?

Overall, 39% of students studied the optional Appendices, though this dropped to 31% for the Unit Appendix, possibly because of pressure from the TMA 02 cut-off date. Median study time for the Appendix was 1 hour.

Interpretation of data for the other optional sections - in unit 8 - is difficult, because of the particularly low response to the relevant question. However, it appears that 40% studied the optional Item A, with a median study time of 1 hour. Only 13% of respondents reported studying optional Item B, with a median study time of 30 minutes.

4. What proportion of students claim that a particular TV programme is totally unhelpful?

With one notable exception the TV programmes were found useful by those who watched (at least 75% of students who viewed said that any one programme was "very" or "fairly"useful). The exception was TV2, which 62% of students said was not useful. Almost all the reasons given for its lack of usefulness were related to the silent animations used in it to demonstrate proofs. Particular criticisms were made to the pace at which the animations developed, and the impression of "jumpiness" or "flashing" given by the changing sequences of lines in the proofs as various parts of the theorem were highlighted.

5. What is the 'normal' time for study associated with a particular TV programme?

Median study time is 35 minutes (excluding viewing time). This is calculated by adding 10 minutes - for reading the introduction to the broadcast notes - to the median time spent on the notes (including SAQ's if used) after the programme. The median has been calculated only for those 75% of viewers who spent any time at all on post-broadcast work.

6. What proportion of students claim that a particular radio programme is totally unhelpful?

No programme so far stands out as being particularly not useful, although Radio 5 was rated rather low, relative to the others: 25% found it "not very" or "not at all" useful. Overall, however, 85% of students who listened found the programmes useful. Of those students who didn't find the programmes helpful the most common reason given was the pace at which they developed (although in fact the majority of all students said that the pace was about right).

7. What is the 'normal' time of study associated with a particular radio programme?

Median study time is 35 minutes (excluding listening time). This is calculated, as for the TV study time, for the 80% of listeners who spent any time at all on the post-broadcast work.

Suggested Courses of Action Concerning Adjustment of Content of M231

1. Units 3 and 14 caused major difficulties for most students in 1974 and called for some remedial attention. Unit 3, particularly, coming so early in the course, was a problem since the inordinate length of study time it required certainly contributed to the serious extent to which many students were behind schedule at almost the beginning of the year. Part of the problem was that students were somewhat mislead by the comparatively easy first couple of units into thinking that the course as a whole would be easy: Unit 3 thus came as something of a shock.

If considered inappropriate, or impossible, to alter either the approach taken in Unit 3 or the amount of material contained in the unit, students could be helped by some warning that this has been found a difficult part of the course, and by an adjustment of the study schedule to allow more time for work on this particular unit. They might also be advised to work through the first couple of units fairly quickly. A further possible source of help could be the provision of extra tutorial help, either in normal class tutorials or at a Saturday School arranged during the period in which students should be working on Unit 3.

2. Students were spending, on average, considerably more than the notional 10/12 hours per unit. Undoubtedly, an important contribution to the high study time was the number of "Problem" sections in each unit. Although the problems in the Optional Sections in each unit were labelled "routine problems" and "harder problems", no such distinction was made between any of the other 20 or so problems set in each unit. Students would certainly be helped by the provision of more guidance as to how they should approach these problems: problems could possibly be graded into easy/difficult, short/long categories so that students could select more easily.

3. The second television programme was a strong candidate for remake. The original programme's assumption that students would have covered the basic concept of limits and epsilon/delta techniques, was misplaced because of the extent to which students were working behind schedule and the difficulty caused by the text itself. A remade programme could discard this assumption and start from basic principles. Animations, if used in the programme, could be slowed down considerably, and students given some more "voice-over" guidance to the development of the proofs in the programme, as, for example, in TV3 and TV5 which students found more helpful.

4. While no radio programme really appears to need remaking, very much more effort could be put into initially motivating students to listen to the programmes.

B. Questions raised in relation to (b): presentation of materials for M332

1. Do students lag behind the officially suggested study schedule and pace themselves against TMA due dates?

The data suggests strongly that TMA due and cut-off dates are the best guide as to when the vast majority of students will have looked at, or perhaps even studied, a particular unit. Students appear to work neither to the schedule of course calendar start dates, nor to the TV schedule.

There is also an indication that students may "have a rest" after submitting an assignment: while there was a long gap between finishing work on Unit 3 (the final unit covered by the first TMA) and starting work on Unit 4, this gap did not persist between Units 4 and 5, nor between Units 5 and 7: it did, however, reoccur between Units 7 and 8. This suggests that students may well see the assignment submission dates as peaks: after each ascent they may stop for a breather, if not from OU work altogether, at least from work on one particular course. It may be that students taking 2 or more half-credit courses prefer to organise their work in 2-week "bursts" on each course consecutively, rather than study several sets of different course material concurrently.

2. What do students think of the SAQ's in the correspondence text?

All but a handful of students claimed to use these SAQ's. Overall, 45% found them difficult, 37% about right, and 11% easy. Difficulty of the SAQ's related positively to difficulty of the units (for example of the early units, SAQ's for Unit 3 - the most difficult unit - were found most difficult, and those for Unit 5 - the easiest unit - least difficult). The vast majority (85%) of students found the SAQ's useful. The course team's original description of these SAQ's as "trivial" is somewhat belied by the finding that almost half the students rated them "difficult", and that so many found them useful. Students' comments indicated that the SAQs were indeed a success - often boosting morale which had been lowered by the more difficult problems.

3. What is the student reaction to the "silent" animations used in the TV programmes?

Overall, students appeared not to be violently against the technique as such, nor were they fervently in favour of it. But a substantial number of students felt that those animations they had seen in the first five television programmes were too fast. When animated proofs were accompanied by at least some voice commentary, students seemed to be much happier with them. However, this was a technique new to most students, and because of the extremely negative reaction to the second programme and the possible "spill-over" from this to later programmes, it is difficult to distinguish the extent to which the silent animation technique itself was unsuccessful from the rather unfortunate way in which it was introduced to students.

4. Do students use the SAQ's in the TV broadcast notes, and if so, how helpful are they?

Overall, 72% of students watching the programmes used the SAQ's, though this had dropped to 66% for TV5, perhaps because of pressure from the second TMA due-date. Shortage of time was the major reason given for not attempting

the SAQ's.

Those students who did use the SAQ's generally found them helpful (at least 80% overall). The few students who gave reasons for not finding them helpful said that it was too easy to answer questions straight after the programme.

5. What is the student reaction to watching someone work through a problem on TV?

Overall, students certainly liked this, primarily as this method was most likely to assist them in getting some idea of how to go about tackling problems, which seemed to be the main general difficulty for students of M231. There was also some feeling that this kind of presentation was better than animation techniques as it more closely resembled a tutorial or classroom situation, and because proofs and problems were "explained" rather than just being "presented".

6. Do the students listen to the radio programmes, and if they do, do they find them helpful? Do they find the written material easy to follow during each broadcast?

It looks as though a very substantial number of students do not listen to the radio programmes. About 60% listened to the first programme, but by the end of the year only about two-fifths - at a generous estimate - of the students were listening. The overwhelming impression, from the interview and questionnaire data, was that radio is regarded as the most expendable component of the course, consequently the component to be sacrificed first when under pressure of work, and the component students are least willing to make an effort to use. Other evaluation studies have suggested that maximising the use made of radio is a problem not just for the Maths Faculty.[7]

Undoubtedly, the majority of those who listened to M231 radio programmes found them useful: as many as 90% (for radio 4) and never less than 72% (for radio 5). Some of this enthusiasm may, of course, be peculiar to this highly selected group of students, who are likely to be considerably more highly motivated than the average.[8] However, the use of radio on M231, being problem-oriented, was found to be a highly suitable one in view of the already mentioned difficulty students are having with the problems.

All but a very few students who listened used the broadcast notes during the radio programmes. For all programmes 25-30% of students said they had some difficulty in following the notes. There was also a positive relationship between usefulness of programmes and ease of following the notes during them.

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[7] Gallagher, M (1975) Broadcast Evaluation Report no. 8: E221 "Caught in the Net".

[8] See Gallagher, M (1975) Broadcast Evaluation Report no. 4: S24 "Industrial Chemistry Component" for further discussion of this point.

7. Do students attempt the non-assessed problems in the TMA's?

Only about half the students attempted these questions for the four assignments. This is poor in comparison with the similar assignment questions on M100, M201 and MST 281. This may be partly attributable to the fact that each TMA contained one question covering one of the four most difficult units in M231. The amount of time that students spent on these units, their difficulty and the fact that the majority were working well behind schedule, may have induced students to avoid the non-assessed questions, which were also in the most difficult in each TMA.

Possible Action Concerning Presentation of M332

1. Evidence that students pace themselves against TMA due and cut-off dates raises the question of television scheduling: if the programmes are scheduled exclusively on the assumption that students "lag behind", a substantial number of students will have read the relevant unit weeks before. This was, in fact, the case in M231. Particularly after the 4 week gap between programmes 3 and 4, many students were well ahead of the material covered on TV (For example, 25% of students had started work on Unit 5 by 2nd April - 20 days before the first transmission of the relevant TV programme 4). Indeed, this was one of the most common reasons given by students for not finding the television programmes useful.

One possible solution might be to move the first transmission forward (where necessary) to the week after the scheduled start date for the relevant unit (in some cases the first transmission of M231 programmes was two, three or even four weeks after the scheduled start date). Data from the study suggests that the top 25% of students were no more than one week behind schedule. If the repeat transmission is kept (as it generally was for M231) back to three weeks after the scheduled start date, then 70-75% of students should have started work on the relevant unit: thus the majority of students would achieve maximum benefit from the broadcasts. A percentage of the remaining students who had not started work on the related unit at the time of the broadcast might, if they watched, find the programme useful as a "pacer".

However, "staggering" repeats in this way presents enormous problems for the University as a whole, when one takes account of the fact that any one half-credit course shares its particular transmission slots with several other half-credit courses (since programmes for any one course are transmitted only every three or four weeks), and that agreement would have

to be reached with all of these course teams, if a "staggered" transmission pattern was to be adopted. Moreover, if the availability of broadcast time continues at its present level, and if courses are produced in their currently predicted numbers, most courses will eventually lose their repeat transmissions and will be left with the very much greater problem of how to maximise the benefit to students of broadcasting programmes once only.

A somewhat simpler, and perhaps more obvious way of approaching the problem indicated by the M231 study would be to move assignment due and cut-off dates closer to the recommended reading dates for relevant printed material. Of course, a fundamental and related question is simply the amount of work expected of students in order to complete both the course as a whole and particular units within the course. If the course, or parts of it, are over-loaded, students will have difficulty in even keeping pace with the assignment dates and will be forced to omit certain course components from their studies.

A further problem raised by the relationship of assignment dates to broadcasts centres on the issue of the range of functions which can be assigned to programmes transmitted at particular times - or at specific points in the "assignment cycle". If, for example, a programme is made dependent on a certain amount of pre-reading, its transmission date should be planned with the knowledge that not only will students need a certain minimum amount of time for preparation, but, depending on the time- relationship between programme transmission and assignment due/cut-off date, that students at particular points of the study year will be more or less able and/or willing to prepare themselves adequately. Consideration of factors such as these should, during the early stages of course planning, influence decisions as to what sorts of programme will be most appropriate at certain times of the year.

2. It seems that, on balance, the silent animation technique need not be rejected. There is nothing to suggest that students in general were particularly "for" or "against" this technique, although some students definitely did dislike it. On the other hand, some students were enthusiastically in favour of the method. Also, it is possible that the technique, if used moderately, may increase concentration, and certainly students did not appear to have difficulty in recalling proofs demonstrated in this way. However, in view of the novelty of the technique and the fact that students were "immersed" in it very early on in only the second programme in the M231 course (a further complication being that this programme dealt with the epsilon delta techniques which students found particularly difficult), it is extremely difficult to distinguish between inherent disadvantages of the technique itself, and problems caused by the way in which it was introduced and applied.

It would seem altogether more reasonable, both to the students, and to the reception of the technique, to introduce new techniques such as that of silent animation much more gradually, building up from simple short animations with some vocal guidance to longer, more complex ones later in the course.

3. In view of the large numbers of students who appear not to listen to any radio programmes, and who may not have done so since early in their Foundation year, very much more effort could be put into "pushing" the radio component at the beginning of the course. If the radio programmes are recognised by students as being closely related to the content and central problems of the unit material, they will be much more likely to listen to at least the first programme on perhaps a "trial" basis. The extent to which they find the programmes helpful in getting to grips with this content and in solving these problems will determine to some degree their listening behaviour for the course.

4. In view of the difficulty, which some students expressed, in concentrating on radio programmes, the use of notes such as those provided in M231 seems a useful way of not only holding students' attention while they listen, but of giving a visual anchor to the programme content after the broadcast. The SAQ's in the notes, which students found helpful, are an extra source of content reinforcement. However, the format of the M231 notes might be examined for possible areas of improvement since a large minority of students did have trouble in following them during the programmes.

5. The extent to which non-assessed problems in TMA's are attempted will depend on a number of factors such as the overall work-load and difficulty of the course, difficulty of assessed TMA questions and the amount of time involved in answering these. However, the difficulty of these non-assessed problems is in itself almost certainly an inhibiting factor: if they looked easier, more students would probably attempt them. Again, perhaps a grading system would help, so that even the less able or motivated student could attempt at least part of the question.